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(71) Applicant: **THE UPJOHN COMPANY**
301 Henrietta Street
Kalamazoo, Michigan 49001(US)

(72) Inventor: **Dugaiczky, Achilles**
c/o The Upjohn Company 301 Henrietta Street
Kalamazoo Michigan 49001(US)

(74) Representative: **Perry, Robert Edward et al,**
GILL JENNINGS & EVERY 53-64 Chancery Lane
London WC2A 1HN(GB)

(54) **Albumin-based nucleotides, their replication and use, and plasmids for use therein.**

(57) The DNA sequence coding for human serum albumin has been isolated and inserted as two fragments into two novel plasmids which can be replicated in *E. coli*. These novel fragments can be joined to provide a unitary DNA sequence which then can be cloned into a suitable host, e.g. *E. coli*, for the expression of human serum albumin (which is used extensively in medical practice in treating shock conditions).

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ALBUMIN-BASED NUCLEOTIDES, THEIR REPLICATION
AND USE, AND PLASMIDS FOR USE THEREIN

This invention relates to nucleotides related to human serum albumin (HSA), their replication and use, and plasmids (and host substances) for use therein.

The gene for serum albumin is regulated in development. On the other hand, serum albumin is synthesised in mammals by the adult liver, and its plateau in adulthood. The embryonic liver and yolk sac, on the other hand, produce predominantly α -fetoprotein, but the synthesis decreases drastically after birth. Recently, Law et al determined the complete sequence of mouse α -fetoprotein mRNA, Nature 291 (1981) 201-205. The structure revealed extensive homology to mammalian serum albumin, indicating that the two proteins are encoded in the same gene family. Similar conclusions have been reached from studies on the α -fetoprotein genes of the rat and the mouse; see Jagodzinski et al, Proc. Natl. Acad. Sci. USA, 78 (1981) 3521-3525, and Gorin et al, J. Biol. Chem. 256 (1981) 1954-1959.

The complete nucleotide sequence of human serum mRNA has been determined from recombinant cDNA clones and from a primer-extended cDNA synthesis on the mRNA template. The sequence comprises 2,078 nucleotides, starting upstream of a potential ribosome binding site in the 5'-untranslated region. It contains all the translated codons and extends into the poly(A) at the 3'-terminus. Part of the translated sequence codes for a hydrophobic prepeptide met-lys-trp-val-thr-phe-ile-ser-leu-leu-phe-leu-phe-ser-ser-ala-tyr-ser, followed by a basic propeptide arg-gly-val-phe-arg-arg. These signal peptides are absent from mature serum albumin and, so far, have not been identified in their nascent state in humans. A remaining 1,755 nucleotides of the translated mRNA sequence code for 585 amino acids which are in agreement, with few exceptions, with the published amino acid data for human serum albumin. The mRNA sequence verifies and refines the repeating homology in the triple-domain structure of the serum albumin molecule.

DETAILED DESCRIPTION OF THE INVENTION

Human serum albumin cDNA is cloned into the PstI site of plasmid pBR322 by the oligo(dG)-oligo(dC) tailing technique. Plasmid DNA was isolated from 97 positive colonies which hybridized to the enriched
 5 albumin cDNA probe, and the recombinant plasmid pHA36 was found to contain the largest insert of an albumin cDNA sequence. Its restriction endonuclease map is shown in the drawing, together with a restriction map of the primer-extended plasmid clone pHA206. The latter was obtained in a second transformation experiment after initiating
 10 the cDNA synthesis from an internal primer. This primer was a 91 base pairs long DNA fragment, MspI(152)-TaqI(182/3), isolated from pHA36. The two plasmids, pHA36 and pHA206, share 0.15 kb of homologous DNA. Together, they encode the entire sequence for human serum albumin, starting with the CTT codon for leu -10 of the prepeptide and extending
 15 into the 3'-untranslated region of poly(A).

Sequence of the Albumin cDNA. The sequence was determined for the most part on both DNA strands to ensure accuracy. All of the restriction sites used to end-label DNA fragments were sequenced across by
 20 labeling a neighboring restriction site. The entire nucleotide sequence of the serum albumin mRNA, as determined from the cloned DNA in pHA36, pHA206, and from the primer-extended cDNA at the 5'-terminus of the message, is shown in the following Table 1. The inferred amino acid sequence is also indicated. The mRNA length is 2,078 nucleotides, of which 38 represent the 5'-untranslated region, 54 identify a
 25 prepeptide of 18 amino acids, 18 identify a propeptide of 6 amino acids, 1,755 code for the known 585 amino acids of serum albumin, 189 make up the 3'-untranslated region and 24 are the poly(A) sequence. Nucleotides 5 to 15 (-34 to -24) in the 5'-untranslated region (Table
 30 1) are complementary to a 3'-terminal region of eukaryotic 18S RNA [Azad, A.A. and Deacon, N.J. (1980) Nuc. Acids Res. 8, 4365-4376] and thus could represent a ribosome binding site:

(5')...T^CT C T T C T G T.....albumin mRNA
 35 (3')...G A G G A A G G C G U C C m₂A⁶ m₂A⁶.....18S RNA

The translated portion of the mRNA sequence codes for the signal peptide and the main body of the albumin polypeptide chain. The

signal peptide is composed of a hydrophobic prepeptide of 18 amino acids and a basic propeptide of 6 amino acids (Table 1). Since pre-peptides are removed from nascent secretory proteins (like albumin) in the endoplasmic reticulum, they are seen only in vitro in heterologous translation systems. As yet, they have not been found within cells [Judah, J.D. and Quinn, P.S. (1977) FEBS 11th Mtg., Copenhagen 50, 21-29; and Strauss, A.W., Donohue, A.M., Bennett, C.D., Rodkey, J.A. and Alberts, A.W. (1977) Proc. Natl. Acad. Sci. USA 74, 1358-1362]. This is the first report of the presence and the sequence of a pre-peptide for human serum albumin. As it is with other secretory proteins, the conversion of proalbumin to albumin takes place in the Golgi vesicles, and the enzyme responsible for this cleavage is probably cathepsin B [Judah, J.D. and Quinn, P.S. (1978) Nature 271, 384-385]. This is also a first report on the sequence of the pro-peptide for normal human serum albumin.

At the 3'-end of the message, the putative polyadenylation signal sequence, AATAAA, is located 164 nucleotides downstream from the amino acid termination codon TAA and 16 nucleotides upstream from the beginning of the poly(A) sequence. Another characteristic sequence located near the polyadenylation site has been identified by Benoist, et al. [Benoist, C., O'Hare, K., Breathnach, R. and Chambon, P. (1980) Nucl. Acids Res. 8, 127-142]; the consensus sequence from several mRNAs was concluded as TTTTCACTGC. A similar sequence, TTTTCTCTGT, is located 19 nucleotides upstream from the AATAAA hexanucleotide in the human albumin mRNA (Table 1).

[illegible]

231 val ser lys leu val thr asp leu thr lys val his thr glu cys cys his gly asp leu leu glu cys ala asp asp arg ala asp leu
 GTT TCC AAG TTA GTG ACA GAT CTT ACC AAA GTC CAC ACC GAA TGC TCC CAT GCA GAT CTG CTT GAA TGT GCT GAT CAC ACG CCG GAC CTT (890)

240 245 246 250 253 260
 261 ala lys tyr ile cys glu asn gln asp ser ile ser ser lys leu lys glu cys cys glu lys pro leu leu glu lys ser his cys ile
 CCC AAG TAT ATC TGT GAA AAT CAA GAT TCG ATC TCC AGT AAA CTG AAG GAA TGC TGT GAA AAA CCT CTG TTG GAA AAA TCG CAC TCG ATT (980)

270 278 279 280 289 290
 291 ala glu val glu asn asp glu met pro ala asp leu pro ser leu ala ala asp phe val glu ser lys asp val cys lys asn tyr ala
 GCC GAA GTG GAA AAT GAT GAG ATG CCT GCT GAC TTG CCT TCA TTA GCT CCT CAT TTT GTT GAA AGT AAG CAT GTT TCG AAA AAC TAT GCT (1070)

300 310 316 320
 321 glu ala lys asp val phe leu gly met phe leu tyr glu tyr ala arg arg his pro asp tyr ser val val leu leu leu arg leu ala
 GAG GCA AAG GAT GTC TTC TTG GCC ATG TTT TTG TAT GAA TAT GCA ACA AGG CAT CCT GAT TAC TCT GTC CTG CTG CTG AGA CTT GCC (1160)

330 340 350
 351 lys thr tyr glu thr thr leu glu lys cys cys ala ala asp pro his glu cys tyr ala lys val phe asp glu phe lys pro leu
 AAG ACA TAT GAA ACC ACT CTA GAG AAG TGC TGT GCC GCT GCA GAT CCT CAT GAA TGC TAT GCC AAA GTG TTC CAT GAA TTT AAA CCT CCT (1250)

360 361 369 370 380
 381 val glu glu pro gln asn leu ile lys gln asn cys glu leu phe glu qln leu qly qly tyr lys phe qln asn ala leu leu val arg
 GTG GAA GAG CCT CAG AAT TTA ATC AAA CAA AAT TGT GAG CTT TTT CAG CAG CAG CTT GCA GAG TAC AAA TTC CAG AAT CCG CTG TTA GTT CGT (1340)

390 392 400 410
 411 thr thr lys lys val pro gln val ser thr pro thr leu val glu val ser arg asn leu qly lys val qly ser lys cys cys lys his
 TAC ACC AAG AAA GTA CCC CAA GTG TCA ACT CCA ACT CTT GTA GAG GTC TCA AGA AAC CTA GCA AAA GTG CCG AGC AAA TGT TGT AAA CAT (1430)

420 430 437 438 440
 441 pro glu ala lys arg met pro cys ala glu asp tyr leu ser val val leu asn gln leu cys val leu his qly lys thr pro val ser
 CCT GAA GCA AAA AGA ATG CCC TGT GCA GAA CAC TAT CTA TCC GTG GTC CTG AAC CAG TTA TGT GTG TTG CAT GAG AAA ACG CCA GTA AGT (1520)

448 450 460 461 470
 471 asp arg val thr lys cys cys thr glu ser leu val asn arg arg pro cys phe ser ala leu glu val asp glu thr tyr val pro lys
 CAC ACA GTC ACC AAA TCC TCC ACA GAA TCC TTG GTG AAC AGG CCA CCA TGC TTT TCA CCT CTG GAA GTC GAT GAA ACA TAC GTT CCC AAA (1610)

476 477 480 490 500
 501 glu phe asn ala glu thr phe thr phe his ala asp ile cys thr leu ser glu lys qly arg qln ile lys lys qln thr ala leu val
 GAG TTT AAT GCT GAA ACA TTC ACC TTC CAT GCA GAT ATA TCC ACA CTT TCT GAG AAG GAG ACA CAA ATC AAG AAA CAA ACT GCA CTT GTT (1700)

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Following are examples which illustrate procedures, ~~including the best mode~~, for practicing the invention. These examples should not be construed as limiting. All percentages are by weight and all solvent mixture proportions are by volume unless otherwise noted.

5 Example 1 Isolation of Messenger RNA

Human liver mRNA was obtained following the procedure of Chirgwin, et al [Chirgwin, J.M., Przybyla, A.E., MacDonald, R.J. and Rutter, W.J. (1979) Biochemistry 18, 5294-5299]. Immunoprecipitation of albumin containing polysomes was performed according to Taylor and
10 Tse [Taylor, J.M. and Tse, T.P.H. (1976) J. Biol. Chem. 251, 7461-7467]. In vitro translation of mRNA was carried out in a reticulocyte cell-free system, following the instruction of the manufacturer (New England Nuclear). The translation products were separated electrophoretically according to Laemmli [Laemmli, J.K. (1970) Nature 227,
15 680-685.

Example 2 Cloning Procedures

Double stranded cDNA was synthesized as described previously [Law, S., Tamaoki, T., Kreuzaler, F. and Dugaiczky, A. (1980) Gene 10, 53-61]. It was annealed to PstI-linearized pBR322 DNA [Rolivar, F.,
20 Rodriguez, R.L., Greene, P.J., Betlach, M.C., Heyneker, H.L., Boyer, H.W., Crossa, J.H. and Falkow, S. (1977) Gene 2, 95-113] that had been tailed with 15 dG residues/3'-terminus [Dugaiczky, A., Robberson, D.L. and Ullrich, A. (1980) Biochemistry 19, 5869-5873]. The annealed DNA was used to transform E. coli strain RR1, as detailed previously [Law, S., et al., Ibid.]. The albumin clones were selected using the colony
25 hybridization method of Grunstein and Hogness [Grunstein, M. and Hogness, D.S. (1975) Proc. Natl. Acad. Sci. USA 72, 3961-3965], with [³²P]-labeled cDNA synthesized with the immunoprecipitated polysomal mRNA as template.

30 As shown in Example 5, plasmids pHA36 and pHA206 were deposited in E. coli HB101 hosts. The plasmids were obtained from E. coli RR1 hosts, described in this example, and transformed into E. coli HB101 by standard procedures well known to those of ordinary skill in this art. The E. coli RR1 hosts were lysed and then centrifuged to
35 separate the chromosomal DNA, cell DNA and plasmid DNA. The plasmid DNA, remaining in the supernatant, is precipitated with ethanol and the precipitate is resuspended in buffer, e.g., TCM (10mM Tris-HCl, pH 8.0, 10 mM CaCl₂, 10 mM MgCl₂). The cells for transformation are

prepared as follows: 120 ml of L-broth (1% tryptone, 0.5% yeast extract, 0.5% NaCl) are inoculated with an 18 hour culture of HB101 NRRL B-11371 and grown to an optical density of 0.6 at 600 nm. Cells are washed in cold 100 mM NaCl and resuspended for 15 minutes in 20 ml chilled 50 mM CaCl₂. Bacteria are then concentrated to one-tenth of this volume in CaCl₂ and mixed 2:1 (v:v) with annealed plasmid DNA, prepared as described above. After chilling the cell-DNA mixture for 15 minutes, it is heat shocked at 42°C for 2 minutes, then allowed to equilibrate at room temperature for ten minutes before addition of L-broth 10 times the volume of the cell-DNA suspension. Transformed cells are incubated in broth at 37°C for one hour before inoculating selective media (L-agar plus 10 µg/ml tetracycline) with 200 µl/plate. Plates are incubated at 37°C for 48 hours to allow the growth of transformants.

15 Example 3 Mapping of Restriction Endonuclease Sites

Restriction endonucleases were obtained from Bethesda Research Laboratories and New England Biolabs and were used according to the manufacturers' instructions. The digested DNA fragments were analyzed electrophoretically on agarose [Helling, R.B., Goodman, H.M. and Boyer, H.W. (1974) J. Virol. 14, 1235-1244] or acrylamide [Dingman, C., Fisher, M.P. and Kakefuda, T. (1972) Biochemistry 11, 1242-1250] gels.

20 Example 4 DNA Sequencing

DNA fragments were dephosphorylated with bacterial alkaline phosphatase (Worthington) and labeled at the 5'-ends with polynucleotide kinase (Boehringer-Mannheim) and γ [³²P]ATP. Following digestion with a second restriction endonuclease and electrophoretic separation of the fragments, DNA sequence determination was done according to the procedure of Maxam and Gilbert [Maxam, A. and Gilbert, W. (1980) Methods Enzym. 65, 499-560] and the degradation products were separated electrophoretically on 0.4 mm acrylamide gels as described by Sanger and Coulson [Sanger, F. and Coulson, R. (1978) FEBS Letters 87, 107-110].

30 Example 5 Recombinant Plasmids pHA36 and pHA206

As disclosed in Example 2, albumin clones were selected by hybridizing to the enriched albumin cDNA probe. Plasmid pHA36 contained the largest insert of an albumin cDNA sequence. Both plasmids pHA36 and pHA206 have been deposited in a viable E. coli host in the

permanent collection of the Northern Regional Research Laboratory (NRRL), U.S. Department of Agriculture, Peoria, Illinois, U.S.A. Their accession numbers in this repository are as follows:

HB101(pHA36) - NRRL B-12551

5 HB101(pHA206) - NRRL B-12550

E. coli HB101 is a known and widely available host microbe. Its NRRL accession number is NRRL B-11371.

NRRL B-12550 and NRRL B-12551 are available to the public. ~~upon the grant of a patent. It should be understood that the availability~~
10 of these deposits does not constitute a license to practice the subject invention in derogation of patent rights granted with the subject instrument by governmental action.

E. coli RR1 and E. coli HB101 are known and widely available host microbes. Their NRRL accession numbers are NRRL B-12186 and NRRL
15 B-11371, respectively.

pBR322 is a well known and widely available plasmid. It can be obtained from the following host deposit by standard procedures:

NRRL B-12014 - E. coli RR1 (pBR322).

YE6 is a well known and widely available yeast episomal plasmid.
20 It can be obtained from the following host deposit by standard procedures:

E. coli HB101 (YE6) - NRRL B-12093.

Example 6 Assembly of the Serum Albumin Gene

Assembling the pieces together is a straightforward task of re-
25 striction enzymology. There is only one MspI site in the overlapping DNA sequence of the two cDNA clones. Two enzymatic steps of (i) MspI digestion of the two DNAs, followed by (ii) the use of ligase, an enzyme that seals DNA fragments, will give the desired product. Although two other undesired DNA species will also be obtained in the
30 course of this recombination reaction, both of them will differ substantially in size. Thus, separation and isolation of the desired DNA species will be achieved.

The assembled DNA clone can be used to transform two types of cells:

- 35 (a) Escherichia coli
(b) Saccharomyces cerevisiae

(a) The vector of choice is plasmid pBR322, the same that has

been successfully used for cloning of the two fragmented pieces of the serum albumin cDNA.

(b) In order to transform yeast with the serum albumin structural gene sequence, the DNA must be inserted into one of the existing yeast plasmid vectors. This can be accomplished by taking advantage of the fact that several restriction endonuclease recognition sequences are absent from the cloned serum albumin DNA. Synthetic EcoRI DNA linkers can be ligated to the DNA fragment containing the serum albumin sequence followed by insertion (ligation) into one of the yeast plasmid vectors, e.g., YEp6, at the Eco RI cloning site. The fused chimeric plasmid can be used to transform yeast according to an established procedure [Hinnen, A., Hicks, J.R. and Fink, G.R. (1978) Proc. Natl. Acad. Sci. USA, 75, 1929]. YEp6 can be obtained from the NRRL repository, as disclosed supra.

15 Example 7 Expression of the Serum Albumin Gene

The main body of the structural gene will be transcribed by the E. coli or yeast enzymes. If little or no albumin is produced with the selected host, then an Escherichia coli promoter DNA sequence carrying an initiation codon, i.e., ATG, can be ligated at the beginning of the serum albumin structural gene. Such elements are known and available, e.g., lac promoter used for the expression of human interferon gene in E. coli [Proc. Natl. Acad. Sci. 77, 5230 (1980)]; source of promoter DNA [Proc. Natl. Acad. Sci. 76, 760 (1979)]. Also, see Nature, Vol. 281, October 18, 1979. It has already been documented that such Escherichia coli promoter sequences function well in the expression of foreign genes in Escherichia coli [Mercereau-Puijalon, O., Royal, A., Cami, B., Garapin, A., Krust, A., Gannon, I. and Kourilsky, P. (1978) Nature 275, 505; and Goeddel, D.V., Kleid, D.G., Bolivar, F., Heyneker, H.L., Yansura, D.G., Grea, R., Hirose, T., Kraszewski, A., Itakura, K., and Riggs, A. (1979) Natl. Acad. Sci. USA 76, 106]. For expression in yeast, see Rose, M., Casadaban, M.J. and Botstein, D. (1981) Proc. Natl. Acad. Sci. USA 78, 2460 and 4466.

25 Example 8 Screening of Clones Producing Albumin

Immunological methods can be used to detect small amounts of albumin made in a bacterium. Flat disks of flexible polyvinyl are coated with the IgG fraction from an immune serum and the disks are pressed onto an agar plate so that antigen released from an in situ lysed microbial colony can bind to the fixed antibody. The plastic

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disk is then incubated with the same total IgG fraction labeled with radioactive iodine so that other determinants on the bound antigen can in turn bind the iodinated antibody. Radioactive areas on the disk expose X-ray film during autoradiography and thus identify colonies producing the protein which is being screened for. Detailed protocols of this procedure have been published [Broome, S. and Gilbert, W. (1978) Proc. Natl. Acad. Sci. USA, 75, 2746]. The purification of human serum albumin can be accomplished by using procedures well known in the art. For example, procedures disclosed in a chapter by T. Peters: Purification and Properties of Serum Albumin, in: The Plasma Proteins, Putnam, Ed. Academic Press, New York, 1975, can be used.

The work described herein was all done in conformity with physical and biological containment requirements specified in the NIH Guidelines.

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CLAIMS

1. Plasmid pHA36, having a restriction endonuclease pattern as shown in the drawing.
- 5 2. Plasmid pHA206, having a restriction endonuclease pattern as shown in the drawing.
- 10 3. E. coli HB101 (pHA36) having the deposit accession number NRRL B-12551.
4. E. coli HB101 (pHA206) having the deposit accession number NRRL B-12550.
- 15 5. A microorganism modified to contain a nucleotide sequence coding for the amino acid sequence of human serum albumin; said nucleotide sequence is as follows:

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 -10
 -1 -6 p r o -1 1
 ser ala tyr ser arg gly val phe arg arg asp ala his lys ser glu val ala his arg phe lys asp leu oly glu asn phe lys
 TCG GCT TAT TCC ACG GGT GTG TTT CGT CCA CAT GCA CAC AAG AGT CAG GTT GCT CAT CGC TTT AAA CAT TTG CCA GAA GAA AAT TTC AAA (170)
 21
 ala leu val leu ile ala phe ala gln tyr leu gln gln cys pro phe glu asp his val lys leu val asn glu val thr glu phe ala
 GCC TTG GTG TTG ATT GCC TTT GCT TAT CTT CAG CAG TGT CCA TTT GAA CAT CAT GTA AAA TTA GTG AAT GAA GTA ACT CAA TTT GCA (260)
 51
 lys thr cys val ala asp glu ser ala glu asn cys asp lys ser leu his thr leu phe oly asp lys leu cys thr val ala thr leu
 AAA ACA TGT GTT GCT CAT CAG TCA GCT GAA AAT TGT GAC AAA TCA CTT CAT ACC CTT TTT CCA CAC AAA TTA TCC ACA GTT GCA ACT CTT (330)
 81
 arg glu thr tyr gly glu met ala asp cys cys ala lys gln glu pro gly arg asn glu cys phe leu gln his lys asp asp asn pro
 CGT GAA ACC TAT GGT CAA ATG GCT CAC TGC TGT GCA AAA CAA GAA CCT GCG ACA AAT GAA TCC TTC TTA CAC AAA GAT CAC AAC CCA (440)
 111
 asn leu pro arg leu val arg pro glu val asp val met cys thr ala phe his asp asn glu glu thr phe leu lys lys tyr leu try
 AAC CTC CCC CCA TTG GTG ACA CCA CAG GTT GAT GTG ATG TGC ACT GCT TTT CAT CAC AAT GAA CAG ACA TTT TTG AAA AAA TAC TTA TAT (530)
 141
 glu ile ala arg arg his pro tyr phe tyr ala pro glu leu leu phe phe ala lys arg tyr lys ala ala phe thr glu cys cys gln
 GAA ATT GCC ACA ACA CAT CCT TAC TTT TAT TAT GCT CCG GAA CTC GAT GAA CTT CCG GAT GAA GCG AAG GCT TCG TCT GCC AAA CAG ACA CTC AAG TGT (620)
 171
 ala ala asp lys ala ala cys leu leu pro lys leu asp glu leu arg asp glu oly lys ala ser ser ala lys gln arg leu lys cys
 GCT GCT GAT AAA GCT GCC TCC CTG TTG CCA AAG CTC GAT GAA CTT CCG GAT GAA GCG AAG GCT TCG TCT GCC AAA CAG ACA CTC AAG TGT (710)
 201
 ala ser leu gln lys phe gly glu arg ala phe lys ala trp ala val ala arg leu ser gln arg phe pro lys ala glu phe ala glu
 GCC AGT CTC CAA AAA TTT GGA GAA ACA GCT TTC AAA CCA TCG CCA GTA GCT CCC CTG ACC CAG ACA TTT CCC AAA GCT GAG TTT GCA CAA (800)
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231 240 245 246 250 253 260
 val ser lys leu val thr asp leu thr lys val his thr glu cys cys his gly asp leu leu glu cys ala asp asp arg ala asp leu
 GGT TCC AAG TTA GTG ACA GAT CTT ACC AAA GTC CAC ACG GAA TGC TGC CAT GGA GAT CTG CTT GAA TGT GCT GAT GAC AGG GCG GAC CTT (890)

261 265 270 278 279 280 289 290
 ala lys tyr ile cys glu asn gln asp ser ile ser ser lys leu lys glu cys cys glu lys pro leu leu glu lys ser his cys ile
 GCC AAG TAT ATC TGT GAA AAT CAA GAT TCG ATC TCC AGT AAA CTG AAG GAA TCC TGT GAA AAA CCT CTG TTG GAA AAA TCC CAC TGC ATT (980)

291 300 310 316 320
 ala glu val glu asn asp glu met pro ala asp leu pro ser leu ala ala asp phe val glu ser lys asp val cys lys asn tyr ala
 GCC CAA GTG GAA AAT GAT CAG ATG CCT GCT CAC TTG CCT TCA TTA GCT GCT GAT TTT GTT GAA AGT AAG GAT GTT TGC AAA AAC TAT GCT (1070)

321 330 340 350
 glu ala lys asp val phe leu gly met phe leu tyr glu tyr ala arg arg his pro asp tyr ser val val leu leu leu arg leu ala
 CAG GCA AAG GAT GTC TTC TTG GGC ATG TTT TTG TAT GAA TAT GCA AGA AGG CAT CCT GAT TAC TCT GTC GTG CTG CTG ACA CTT GCC (1160)

351 360 361 369 370 380
 lys thr tyr glu thr thr leu glu lys cys cys ala ala asp pro his glu cys tyr ala lys val phe asp glu phe lys pro leu
 AAG ACA TAT GAA ACC ACT CTA CAG AAG TGC TGT GCT GCT GCA GAT CCT CAT GAA TGC TAT GCC AAA GTG TTC CAT GAA TTT AAA CCT CCT (1250)

381 390 392 400 410
 val glu glu pro gln asn leu ile lys gln asn cys glu leu phe glu qln leu gly glu tyr lys phe qln asn ala leu leu val arg
 GTG GAA CAG CCT CAG AAT TTA ATC AAA CAA AAT TGT GAG CAG CTT TTT GAG CAG CTT GCA GAG TAC AAA TTC CAG AAT CCG CTG TTA GTT CGT (1340)

411 420 430 437 438 440
 tyr thr lys lys val pro gln val ser thr pro thr leu val glu val ser arg asn leu qly lys val qly ser lys cys cys lys his
 TAC ACC AAG AAA GTA CCC CAA GTG TCA ACT CCA ACT CTT GTA CAG GTC TCA AGA AAC CTA GGA AAA GTG GGC AGC AAA TGT TGT AAA CAT (1430)

441 448 450 460 461 470
 pro glu ala lys arg met pro cys ala glu asp tyr leu ser val val leu asn gln leu cys val leu his qlu lys thr pro val ser
 CCT GAA GCA AAA AGA ATG CCC TGT GCA GAA GAC TAT CTA TCC GTG GTC CTG AAC CAG TTA TGT GTG TTG CAT GAG AAA ACG CCA GTA AGT (1520)

471 476 477 480 490 500
 asp arg val thr lys cys cys thr glu ser leu val asn arg arg pro cys phe ser ala leu glu val asp qlu thr tyr val pro lys
 CAC ACA GTC ACC AAA TGC TGC ACA TCC TTG GTG AAC AGG CGA CCA TCC TTT TCA GCT CTG GAA GTC GAT GAA ACA TAC GTT CCC AAA (1610)

501 510 514 520 530
 glu phe asn ala glu thr phe thr phe his ala asp ile cys thr leu ser glu lys glu arg qln ile lys lys qln thr ala leu val
 GAG TTT AAT GCT GAA ACA TTC ACC TTC CAT GCA GAT ATA TCC ACA CTT TCT GAG AAG GAG AGA CAA ATC AAG AAA CAA ACT GCA CTT GTT (1700)

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531 558 559 560
glu leu val lys his lys pro lys ala thr lys glu gln leu lys ala val met asp asp phe ala ala phe val glu lys cys cys lys
GAG CTC GTG AAA CAC AAG CCC AAG GCA ACA AAA GAG CAA CTG AAA GCT GTT ATG GAT GAT TTC GCT GCT TTT GTA GAG AAG TGC AAG (1790)

561 567 570 580
ala asp asp lys lys glu thr cys phe ala glu glu gln lys lys leu val ala ala ser gln ala ala leu gly leu ter
GCT GAC GAT AAG GAG ACC TGC TTT GCC GAG GAG GGT AAA AAA CTT GCT GCA AGT CAA GCT GCC TTA GGC TTA TAA CATCACATTTAAAG (1883)

ter ter
CATCTCAGCCTACCATGAGCAATAAGAGAGAAAGCAATGAGCATCAAAAGCTTATTCATCTGTTTTCTTTTTCGTTGGTGTAAAGCCACACCCCTGCTCTAAAAACATAAATTTCTTAA (2002)

TCATTTTGCCTCTTTTCTCTGCTTCAATTAATAAAATGGAAGATCTAA..... 20AA (2078)

6. Nucleotide sequence of the cDNA of human serum albumin, said nucleotide sequence is as follows:

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1      10      20
asp ala his lys ser glu val ala his arg phe lys asp leu gly glu gln phe lys
GAT CCA CAC CAC AAG AGT CAG GTT GCT CAT CCG TTT AAA GAT TTG CCA GAA AAT TTC AAA (170)

21      30      40      50
ala leu val leu ile ala phe ala gln tyr leu gln gln cys pro phe glu asp his val lys leu val asn glu val thr gln phe ala
GCC TTG CTG TTG ATT GCC TTT GCT CAG TAT CTT CAG CAG TGT CCA TTT GAA CAT CAT GTA AAA TTA GTG AAT GAA GTA ACT CAA TTT CCA (260)

51      60      70      75      80
lys thr cys val ala asp glu ser ala glu asn cys asp lys ser leu his thr leu phe gly asp lys leu cys thr val ala thr leu
AAA ACA TGT GTT GCT CAT CAG TCA GCT GAA AAT TGT GAC AAA TCA CTT CAT ACC CTT TTT CCA GAC AAA TTA TCC ACA GTT GCA ACT CTT (350)

81      90      91      100      101
arg glu thr tyr gly glu met ala asp cys cys ala lys gln glu pro gly arg asn glu cys phe leu gln his lys asp asp asn pro
CGT CAA ACC TAT GGT CAA ATG GCT GAC TGC TGT GCT CCA AAA CAA CAA CCT GCG ACA AAT CAA TCC TTC TTG CAA CAC AAA GAT GAC AAC CCA (440)

111      120      124      130      140
asn leu pro arg leu val arg pro glu val asp val met cys thr ala phe his asp asn glu thr phe leu lys lys tyr leu try
AAC CTC CCC CCA TTG GTG ACA CAG CTT GAT GTG ATG TGC ACT GCT TTT CAT GAC AAT CAA CAG ACA TTT TTG AAA AAA TAC TTA TAT (530)

141      150      160      168      169      170
glu ile ala arg arg his pro tyr phe tyr ala pro glu leu leu phe phe ala lys arg tyr lys ala ala phe thr glu cys cys gln
CAA ATT GCC ACA ACA CAT CCT TAC TTT TAT TAT TAT TAT TAT TAT TAT TAT TAT TAT TAT TAT TAT TAT TAT TAT TAT TAT TAT TAT (620)

171      177      180      190      200
ala ala asp lys ala ala cys leu leu pro lys leu asp glu leu arg asp glu gln lys ala ser ser ala lys gln arg leu lys cys
GCT GCT CAT AAA GCT GCC TGC CTG TTG CCA AAG CTC GAT GAA CTT CCG GAT GAA GGG AAG GCT TCG TCT GCC AAA CAG ACA CTC AAG TGT (710)

201      210      220      230
ala ser leu gln lys phe gly glu arg ala phe lys ala trp ala val ala arg leu ser gln arg phe pro lys ala gln phe ala gln
GCC AGT CTC CAA AAA TTT CCA GAA ACA GCT TTC AAA CCA TGG CCA GTA CCT CCG CTC AGC CAG ACA TTT CCC AAA GCT GAG TTT GCA GAA (800)

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231	240	245 246	250	253	260
val ser lys leu val thr asp leu thr lys val his thr glu cys cys his gly asp leu leu glu cys ala asp asp arg ala asp leu					
GTT TCC AAG TTA GTG ACA GAT CTT ACC AAA GTC CAC ACG GAA TCC TGC CAT GCA GAT CTG CTT GAA TGT CCT CAT CAC AGG CCG GAC CTT (890)					
261	270	278 279 280			289 290
ala lys tyr ile cys glu asn gln asp ser ile ser ser lys leu lys glu cys cys glu lys pro leu leu glu lys ser his cys ile					
CCC AAG TAT ATC TGT TGT GAA AAT CAA GAT TCG ATC TCC AGT AAA CTG AAG GAA TGC TGT GAA AAA CCT CTG TTG GAA AAA TCT CAC TCC ATT (980)					
291	300	310	316	320	
ala glu val glu asn asp glu met pro ala asp leu pro ser leu ala ala asp phe val glu ser lys asp val cys lys asn tyr ala					
CCC GAA GTG GAA AAT CAT CAG ATG CCT CCT GAC TTG CCT TCA TTA GCT GCT GAT TTT GTT GAA AGT AAG CAT GTT TGC AAA AAC TAT CCT (1070)					
321	330	340		350	
glu ala lys asp val phe leu gly met phe leu tyr glu tyr ala arg arg his pro asp tyr ser val val leu leu leu arg leu ala					
CAG GCA AAG CAT GTC TTC TTG CCC ATG TTT TTG TAT GAA TAT GCA AGA AGG CAT CCT CAT TAC TCT GTC GTG CTG CTG ACA CTT GCC (1160)					
351	360 361	369 370		380	
lys thr tyr glu thr thr leu glu lys cys cys ala ala asp pro his glu cys tyr ala lys val phe asp glu phe lys pro leu					
AAG ACA TAT GAA ACC ACT CTA GAG AAG TCC TGT TGT CCT GCA GAT CCT CAT GAA TCC TAT GCC AAA GTG TTC GAT GAA TTT AAA CCT CCT (1250)					
381	390 392	400		410	
val glu glu pro gln asn leu ile lys gln asn cys glu leu phe glu leu gly glu tyr lys phe gln asn ala leu leu val arg					
GTG GAA CAG CCT CAG AAT TTA ATC AAA CAA AAT TGT CAG CTT TTT GAG CAG CTT GCA GAG TAC AAA TTC CAG AAT CCG CTG TTA GTT CGT (1350)					
411	420	430	437 438	440	
tyr thr lys lys val pro gln val ser thr pro thr leu val glu val ser arg asn leu gly lys val gly ser lys cys cys lys his					
TAC ACC AAG AAA GTA CCC CAA GTG TCA ACT CCA ACT CTT GTA GAG GTC TCA ACA AAC CTA GCA AAA GTG GCC ACC AAA TGT TGT AAA CAT (1430)					
441	448 450	460 461		470	
pro glu ala lys arg met pro cys ala glu asp tyr leu ser val val leu asn gln leu cys val leu his glu lys thr pro val ser					
CCT CAA GCA AAA ACA ATG CCC TGT GCA GAA GAC TAT CTA TCC GTG GTC CTG AAC CAG TTA TGT GTG TTG CAT CAG AAA ACG CCA GTA AGT (1520)					
471	476 477	480		500	
asp arg val thr lys cys cys thr glu ser leu val asn arg arg pro cys phe ser ala leu glu val asp glu thr tyr val pro lys					
GAC ACA GTC ACC AAA TCC TCC ACA GAA TCC TTG GTG AAC AGG CCA CCA TGC TTT TCA GCT CTG GAA GTC GAT GAA ACA TAC GTT CCC AAA (1610)					
501	510	514	520	530	
glu phe asn ala glu thr phe thr phe his ala asp ile cys thr leu ser glu lys glu arg gln ile lys lys gln thr ala leu val					
CAG TTT AAT GCT GAA ACA TTC ACC TTC CAT GCA GAT ATA TCC ACA CTT TCT GAG AAG GAG ACA CAA ATC AAG AAA CAA ACT GCA CTT GTT (1700)					

[illegible]

231 val ser lys leu val thr asp leu thr lys val his thr glu cys cys his gly asp leu leu glu cys ala asp asp arg ala asp leu 260
 GTT TCC AAG TTA GTG ACA CAT CTT ACC AAA GTC CAC ACG GAA TGC TGC CAT GCA CAT CTG CTT GAA TGT GCT CAT CAC AGG CCG CAC CTT (890)

261 ala lys tyr ile cys glu asn gln asp ser ile ser ser lys leu lys glu cys cys glu lys pro leu leu glu lys ser his cys ile 289 290
 CCC AAG TAT ATC ATC TGT GAA AAT CAA CAT TCG ATC TCC AGT AAA CTC AAG GAA TGC TGT GAA AAA CCT CTG TTG GAA AAA TCC CAC TGC ATT (980)

291 ala glu val glu asn asp glu met pro ala asp leu pro ser leu ala ala asp phe val glu ser lys asp val cys lys asn tyr ala 320
 GCC GAA GTG CAA AAT CAT CAG ATC CCT GCT CAC TTG CCT TCA TTA CCT GCT CAT TTT GTT CAA AGT AAG CAT GTT TGC AAA AAC TAT GCT (1070)

321 glu ala lys asp val phe leu gly met phe leu tyr glu tyr ala arg arg his pro asp tyr ser val val leu leu leu arg leu ala 350
 CAG GCA AAG CAT GTC TTC TTG CCG ATG TTT TTG TAT GAA TAT GCA AGA AGG CAT CCT CAT TAC TCT GTC GTG CTG CTG AGA CTT GCC (1160)

351 lys thr tyr glu thr thr leu glu lys cys cys ala ala asp pro his glu cys tyr ala lys val phe asp glu phe lys pro leu 380
 AAG ACA TAT GAA ACC ACT CTA CAG AAG TGC TGT GGC GCT CCA CAT CCT CAT GAA TGC TAT GCC AAA GTG TTC CAT GAA TTT AAA CCT CCT (1250)

381 val glu glu pro gln asn leu ile lys gln asn cys glu leu phe glu gln leu qly glu tyr lys phe gln asn ala leu leu val arg 410
 GTG GAA GAG CCT CAG AAT TTA ATC AAA CAA AAT TGT GAG CTT TTT GAG CAG CTT GCA GAG TAC AAA TTC CAG AAT GCG CTG TTA GTT CGT (1360)

411 tyr thr lys lys val pro gln val ser thr pro thr leu val glu val ser arg asn leu qly lys val qly ser lys cys lys his 440
 TAC ACC AAG AAA GTA CCC CAA GTG TCA ACT CCA ACT CTT GTA GAG GTC TCA ACA AAC CTA GCA AAA GTG GCG ACC AAA TGT TGT AAA CAT (1430)

441 pro glu ala lys arg met pro cys ala glu asp tyr leu ser val val leu asn gln leu cys val leu his glu lys thr pro val ser 470
 CCT GAA GCA AAA AGA ATA CCC TGT GCA GAA GAC TAT CTA TCC GTG GTC CTG AAC CAG TTA TGT GTG TTG CAT GAG AAA ACG CCA GTA AGT (1520)

471 asp arg val thr lys cys cys thr glu ser leu val asn arg arg pro cys phe ser ala leu glu val asp glu thr tyr val pro lys 500
 CAC ACA GTC ACC AAA TCC TCC ACA GAA TCC TTG GTG AAC AGG CCA CCA TCC TTT TCA GCT CTG GAA GTC CAT GAA ACA TAC GTT CCC AAA (1610)

501 glu phe asn ala glu thr phe thr phe his ala asp ile cys thr leu ser glu lys glu arg gln ile lys lys gln thr ala leu val 530
 CAG TTT AAT CCT GAA ACA TTC ACC TTC CAT GCA CAT ATA TCC ACA CTT TCT GAG AAG GAG AGA CAA ATC AAG AAA CAA ACT GCA CTT GTT (1700)

35

	35	30	25	20	15	10	5
	-1	-6	p	r	o	-1	1
ser ala tyr ser arg gly val phe arg arg asp ala his lys ser glu val ala his arg phe lys asp leu aly glu glu asn phe lys							20
TGC GCT TAT TCC ACG GGT GTG TTT CGT CGA GAT GCA CAC MAG AGT GAG GTT GCT CAT CGC TTT AAA GAT TTG CCA GAA GAA AAT TTC AAA							(170)
21			30				50
ala leu val leu lle ala phe ala gln tyr leu gln cys pro phe glu asp his val lys leu val asn glu val thr alu phe ala			34				
GGC TTG GTG TTG ATT GCC TTT GCT CAG TAT CTT CAG CAG TGT CCA TTT GAA GAT CAT GTA AAA TTA GTG AAT GAA GTA ACT CAA TTT GCA							(260)
51	53		60	62		70	75
lys thr cys val ala asp glu ser ala glu asn cys asp lys ser leu his thr leu phe gly asp lys leu cys thr val ala thr leu							
AAA ACA TGT GTT GCT GAT GAG TCA GCT GAA AAT TGT GAC AAA TCA CTT CAT ACC CTT TTT CCA GAC AAA TTA TGC ACA GTT CCA ACT CTT							(350)
81			90	91		100	101
arg glu thr tyr gly glu met ala asp cys cys ala lys gln glu pro gly arg asn glu cys phe leu gln his lys asp asn pro							
CCG GAA ACC TAT GGT GAA ATG GCT GAC TGC TGT GCA AAA CAA GAA CCT GGG AGA AAT GAA TGC TTC TTG CAA CAC AAA GAT GAC AAC CCA							(660)
111			120		124	130	150
asn leu pro arg leu val arg pro glu val asp val met cys thr ala phe his asp asn glu thr phe leu lys lys tyr leu tyr							
AAC CTC CCC CGA TTG GTG AGA CCA GAG GTT GAT GTG ATG TGC ACT GCT TTT CAT GAC AAT GAA CAG ACA TTT TTG AAA AAA TAC TTA TAT							(330)
141			150		160		168 169 170
glu lle ala arg arg his pro tyr phe tyr ala pro glu leu leu phe phe ala lys arg tyr lys ala phe thr alu cys cys gln							
GAA ATT GCC AGA AGA CAT CCT TAC TTT TAT GCC CCG GAA CTC CTT TTT GCT AAA AGG TAT AAA GCT GCT TTT ACA GAA TGT TGC CAA							(420)
171		177	180		190		200
ala ala asp lys ala ala cys leu leu pro lys leu asp glu leu arg asp alu gly lys ala ser ala lys aln arg leu lys cys							
GCT GCT GAT AAA GCT GCC TGC CTG TTG CCA MAG CTC GAT GAA CTT CGG GAT GAA GGG AAG GCT TCG TCT GCC AAA CAG ACA CTC MAG TGT							(710)
201			210		220		230
ala ser leu gln lys phe gly glu arg ala phe lys ala trp ala val ala arg leu ser gln arg phe pro lys ala alu phe ala alu							
CCC AGT CTC CAA AAA TTT GGA GAA AGA GCT TTC AAA GCA TGG GCA GTA GCT CCC CTC ACC CAG AGA TTT CCC AAA GAT GAG TTT GCA CAA							(300)

231 val ser lys leu val thr asp leu thr lys val his thr glu cys oys his gly asp leu leu glu cys ala asp asp arg ala asp leu 260
 GYT TCC AAG TTA GTG ACA GAT CTT ACC AAA GTC CAC ACG GAA TCC TCC CAT GCA CAT CTG CTT GAA TGT GCT GAT CAC AGC GCG GAC CTT (890)
 261 ala lys tyr ile cys glu asn gln asp ser ile ser ser lys leu lys glu cys glu lys pro leu leu glu lys ser his cys ile 289 290
 GCC AAG TAT ATC TGT TGT GAA AAT CAA GAT TCG ATC TCC AGT AAA CTG AAG GAA TCC TGT GAA AAA CCT CTG TTC GAA AAA TCC CAC TCC ATT (980)
 291 ala glu val glu asn asp glu met pro ala asp leu pro ser leu ala ala asp phe val glu ser lys asp val cys lys asn tyr ala 320
 GCC GAA GTG GAA AAT GAT GAG ATG CCT GCT GAC TTG CCT TCA TTA GCT GCT GAT TTT GTT GAA AGT AAG GAT GTT TGC AAA AAC TAT GCT (1070)
 321 glu ala lys asp val phe leu glu met phe leu tyr glu tyr ala arg arg his pro asp tyr ser val val leu leu leu arg leu ala 350
 GAG GCA AAG GAT GTC TTC TTG GGC ATG TTT TTG TAT GAA TAT GCA AGA ACG CAT CCT GAT TAC TCT GTC GTG CTG CTG AGA CTT GCC (1160)
 351 lys thr tyr glu thr thr leu glu lys oys cys ala ala asp pro his glu cys tyr ala lys val phe asp glu phe lys pro leu 380
 AAG ACA TAT GAA ACC ACT CTA GAG AAG TGC TGT GCC GCT GCA GAT CCT CAT GAA TGC TAT GCC AAA GTG TTC GAT GAA TTT AAA CCT CCT (1250)
 381 val glu glu pro gln asn leu ile lys gln asn cys glu leu phe glu leu oys glu tyr lys phe gln asn ala leu leu val arg 410
 GTG GAA GAG CCT CAG AAT TTA ATC AAA CAA AAT TGT GAG CTT TTT GAG CAG CTT GCA GAG TAC AAA TTC CAG AAT GCG CTG TTA GTT CGT (1340)
 411 tyr thr lys lys val pro gln val ser thr pro thr leu val glu val ser arg asn leu gly lys val gly ser lys cys cys lys his 440
 TAC ACC AAG AAA GTA CCC CAA GTG TCA ACT CCA ACT CTT GTA GAG GTC TCA ACA AAC CTA GCA AAA GTG GCG AGC AAA TGT TGT AAA CAT (1430)
 441 pro glu ala lys arg met pro cys ala glu asp tyr leu ser val val leu asn gln leu cys val leu his glu lys thr pro val ser 470
 CCT GAA GCA AAA ACA ATG CCC TGT GCA GAA GAC TAT CTA TCC GTG GTC CTG AAC CAG TTA TGT GTG TTG CAT GAG AAA ACG CCA GTA AGT (1520)
 471 asp arg val thr lys cys cys thr glu ser leu val asn arg pro cys phe ser ala leu glu val asp glu thr tyr val pro lys 500
 GAC AGA GTC ACC AAA TCC TCC ACA GAA TCC TTG GTG AAC ACG CCA CCA TCC TTT TCA CCT CTG CAA GTC GAT GAA ACA TAC GTT CCC AAA (1610)
 501 glu phe asn ala glu thr phe thr phe his ala asp ile cys thr leu ser glu lys glu arg gln ile lys lys gln thr ala leu val 530
 GAG TTT AAT GCT GAA ACA TTC ACC TTC CAT CCA CAT ATA TCC ACA CTT TCT GAG AAG GAG ACA CAA ATC AAG AAA CAA ACT GCA CTT GTT (1700)

5
10
15
20
25
30
35

531
glu leu val lys his lys pro lys ala thr lys glu gln leu lys ala val met asp phe ala ala phe val glu lys cys lys
CAG CTC GTG AAA CAC AAG CCC AAG CCA ACA AAA CAG CAA CTG AAA GCT GTT ATG GAT CAT TTC GCT TTT GTA GAG AAG TGC AAG (1790)

540
550
558 559 560

561
ala asp asp lys glu thr cys phe ala glu glu qly lys lys leu val ala ala ser gln ala ala leu qly leu ter
CCT CAC GAT AAG GAG ACC TGC TTT GCC GAG GAG GGT AAA AAA CTT GTT GCT GCA AGT CAA GCT GCC TTA GGC TTA TAA CATCACATTAAAG (1883)

567
570
580

ter ter
CATCTCAGCCTACCATGAGATAACAGAGAAATGACATCAAAAGCTTATTCATCTGTGTTTTCTTTTTCTGTTGTTAAAGCCACACCCCTGCTCTAAAAACATAAATTCCTTAA (2002)

TCATTTTGGCCCTCTTTCTCTGCTTCATTAATAAAAAATGGAAGAAATCTAA..... 20AA (2078)

10. A nucleotide sequence according to any of claims 6 to 9, in essentially pure form.
11. A DNA transfer vector comprising a nucleotide sequence as defined in claim 5.
- 5 12. A DNA transfer vector according to claim 11, transferred to and replicated in a micro-organism.
13. A DNA transfer vector according to claim 12, which is a plasmid.
14. A DNA transfer vector according to claim 13,
10 wherein the plasmid is pBR322 or YEp6.
15. A process for preparing human serum albumin, which comprises culturing a micro-organism according to claim 5.
16. A DNA transfer vector according to any of
15 claims 12 to 14, or a process according to claim 15, wherein the micro-organism is a bacterium or yeast.
17. A vector or process according to claim 16, wherein the bacterium or yeast is E. coli or Saccharomyces cerevisiae.

Restriction Endonuclease Map of Human Serum Albumin cDNA Clones

pHA36

